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A144 005

Air Force

Headquarters, USAF
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Studies & Analyses

Clear Skies At Altitude

A Paper By

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MAY 1983

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ACKNOWLEDGEMENTS

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ABSTRACT

Estimates of the Probability of Maintaining Clear Conditions at Altitude
by
Lt Colonel Roger E. Christensen

This paper provides estimates of the probabilities of remaining in-the-clear on 0 to 1000 nautical mile flights at a constant altitude within the European, Korean, and Mideast theaters. The estimates are based upon correlation studies of cloud observations by the Air Force Geophysics Laboratory and the USAF Environmental Technical Applications Center. The methodology for computing the probabilities is presented.

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EXECUTIVE SUMMARY

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BACKGROUND

This paper was written to address the question, "What is the probability of being in-the-clear at a given altitude over a given location, and how does this probability change as a function of distance flown from the initial location?"

DISCUSSION

A USAF Environmental Technical Applications Center (USAFETAC) report on the Vertical Distribution of Clouds provides probabilities of clear skies at a location for various altitudes for Europe, Korea, and the Mideast. Furthermore, studies by the Air Force Geophysics Laboratory and USAFETAC show that cloud conditions and associated probabilities steadily become unrelated or independent of each other with distance. This makes possible the use of probabilities of clear conditions at a point to infer probabilities of clear conditions as a function of distance traveled. In the upper atmosphere, generally above 6000 feet altitude, the distance where independence occurs is on the order of 600 nautical miles. In the lower atmosphere which is greatly influenced by the underlying terrain, this distance is on the order of 175 miles.

Figure 1 illustrates how probabilities of clear skies vary with altitude over central Europe during winter and summer.

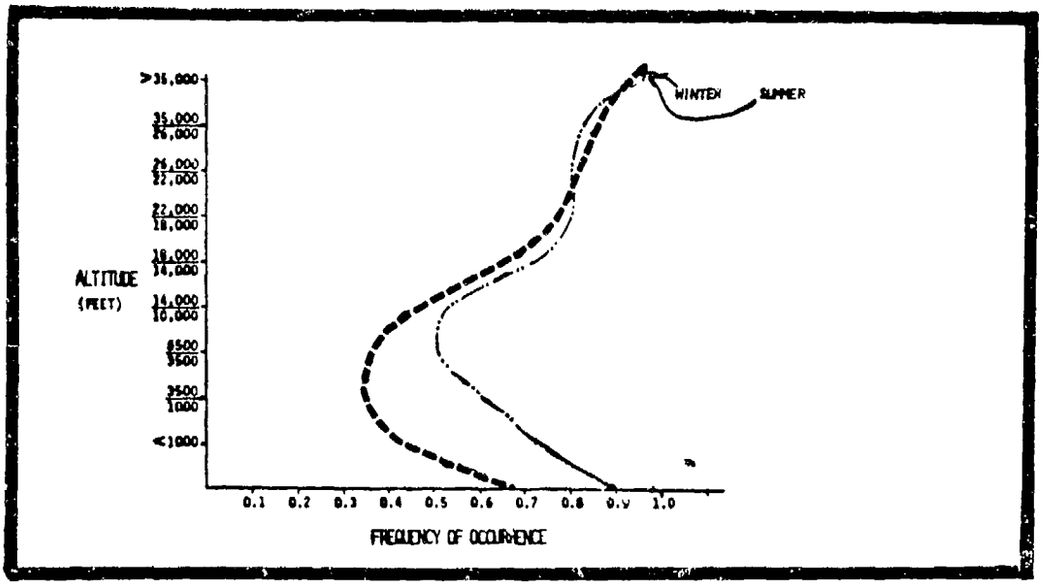

Figure 1. Probability of Clear Skies at Altitude (Central Europe)

For example, the probability of an airplane being in-the-clear at altitudes between 3500 and 6500 feet at any given location in Central Europe during the winter is approximately 34 percent. Near the surface, the probability improves to about 67 percent.

Figures 2 and 3 illustrate how the probability of staying in-the-clear decreases as one flies at low and high altitudes in a given theater of operation. Along the ordinate of Figure 2 and 3 is the probability of clear skies at a location in the theater concerned. Along the direction of the abscissa, the probability of staying in-the-clear steadily decreases because of the increasing likelihood of flying into clouds with distance flown. Separate curves are provided for day and night situations.

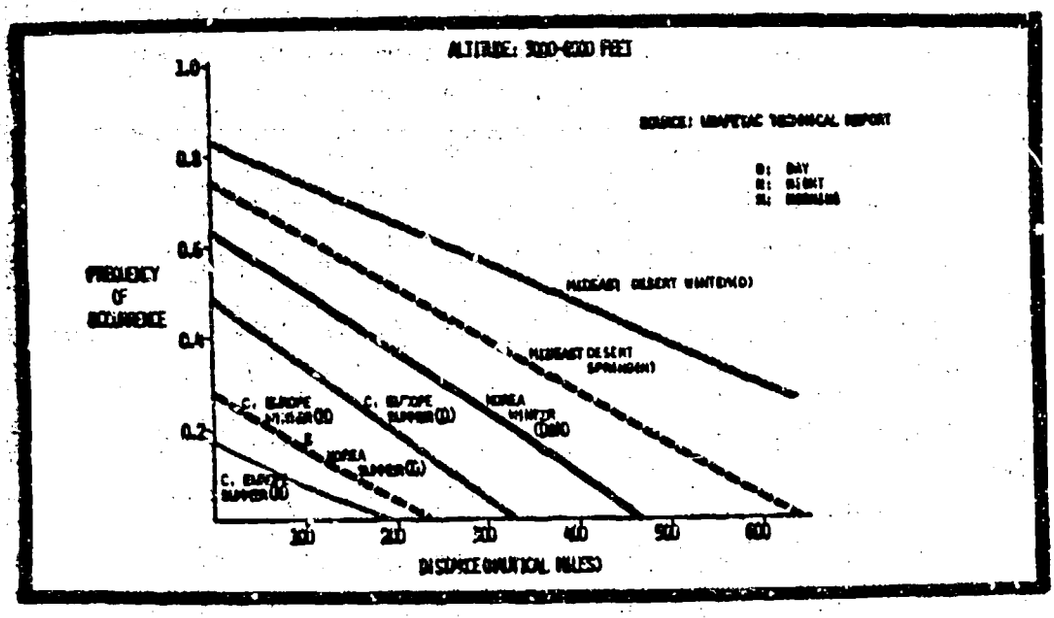

Figure 2. Staying Cloud-Free with Distance

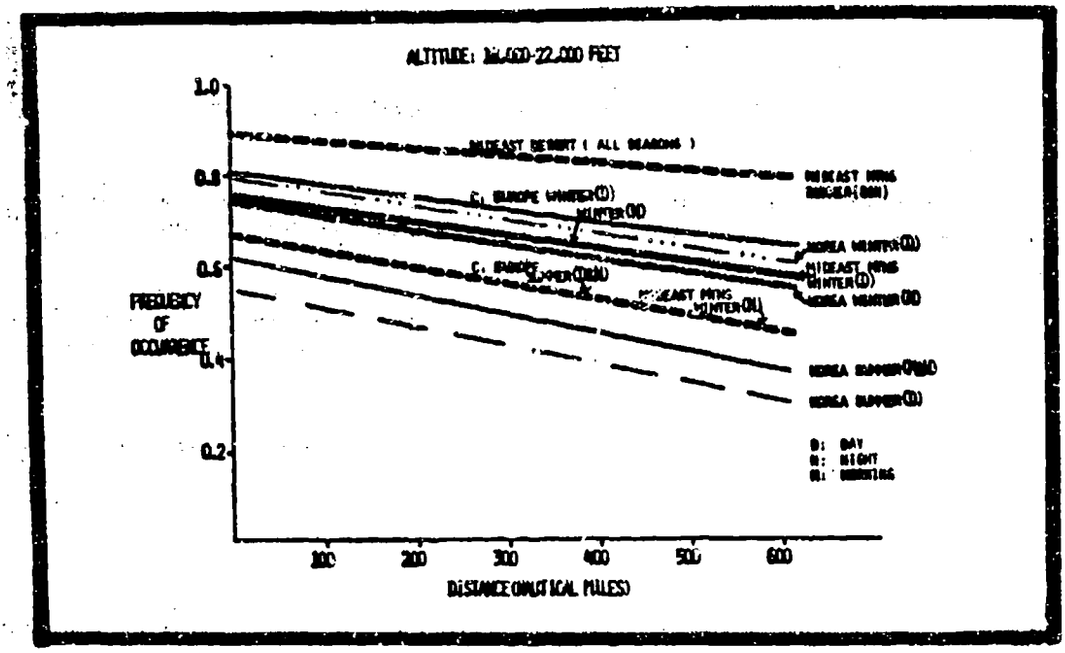

Figure 3. Staying Cloud-Free with Distance

Information for other altitudes for north central and south central Europe, North and South Korea, and mountains and desert area of the Mideast is available in the main report in a format like that in Table 1. Zero distance probabilities are the probabilities of being in-the-clear at any given location in the theater concerned.

TABLE 1 PROBABILITIES OF MAINTAINING CLEAR SKIES AT ALTITUDE OVER VARIOUS DISTANCES

CENTRAL EUROPE - SOUTHERN MOUNTAINS

ALTITUDE (Ft)	*	DISTANCE (MILES) 0			100			200			400			600			1000		
		M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
≥35,000	W	.93	.96	.95	.92	.95	.94	.91	.95	.93	.89	.93	.92	.86	.92	.90	.82	.90	.87
	S	.96	.97	.95	.95	.97	.94	.95	.96	.93	.93	.95	.92	.92	.94	.90	.90	.92	.87
35,000	W	.86	.89	.83	.84	.87	.81	.82	.86	.78	.78	.82	.74	.74	.79	.69	.66	.73	.59
26,000	S	.84	.87	.83	.82	.85	.81	.80	.83	.78	.75	.75	.74	.71	.76	.69	.62	.68	.59
26,000	W	.82	.82	.75	.80	.80	.72	.77	.77	.69	.72	.72	.63	.67	.67	.56	.57	.57	.44
22,000	S	.81	.84	.77	.78	.82	.74	.76	.80	.71	.71	.75	.65	.66	.71	.59	.55	.62	.47
22,000	W	.77	.78	.73	.74	.75	.70	.71	.72	.66	.65	.67	.60	.59	.61	.53	.47	.49	.40
18,000	S	.80	.80	.76	.77	.77	.73	.75	.75	.70	.69	.69	.64	.64	.64	.58	.53	.53	.46
18,000	W	.65	.66	.59	.61	.62	.55	.57	.59	.51	.50	.51	.43	.42	.44	.35	.27	.29	.19
14,000	S	.73	.71	.69	.70	.68	.65	.66	.64	.62	.60	.57	.55	.53	.50	.48	.40	.37	.33
14,000	W	.44	.45	.42	.40	.41	.38	.36	.37	.34	.28	.29	.26	.19	.20	.18	.03	.04	.01
10,000	S	.53	.50	.50	.49	.46	.46	.45	.42	.42	.36	.33	.33	.28	.25	.25	.11	.08	.08
10,000	W	.36	.37	.37	.23	.24	.24	.10	.10	.10	-	-	-	-	-	-	-	-	-
6,500	S	.50	.46	.37	.36	.32	.24	.21	.18	.10	-	-	-	-	-	-	-	-	-
6,500	W	.34	.33	.30	.24	.20	.18	.10	.07	.06	-	-	-	-	-	-	-	-	-
3,500	S	.55	.47	.24	.41	.33	.14	.27	.19	.03	-	-	-	-	-	-	-	-	-
3,500	W	.40	.39	.34	.26	.25	.21	.13	.12	.08	-	-	-	-	-	-	-	-	-
1,000	S	.71	.58	.49	.59	.44	.35	.47	.30	.20	.24	02	-	.00	-	-	-	-	-
< 1,000	W	.66	.66	.70	.53	.53	.58	.40	.40	.46	.15	.15	.22	-	-	-	-	-	-
	S	.89	.80	.90	.83	.71	.85	.76	.62	.60	.67	.43	.69	.55	.25	.59	.33	-	.39

M: MORNING
A: AFTERNOON
N: NIGHT

W: WINTER
S: SUMMER

OBSERVATIONS

i. The lowest probabilities of clear skies are between 1,000 and 10,000 feet above ground-level (AGL) in Europe and Korea, and between 6,500 and 14,000 feet above mean sea level (MSL) in the Mideast.

ii. Probabilities of clear skies increase with increasing altitude above 14,000 feet MSL. Seasonal differences above 14,000 feet are small regardless of theater.

iii. Probabilities of clear skies increase with decreasing altitude below 1,000 feet AGL, indicating the importance of being able to fly low so as to stay "under-the-weather." Seasonal differences below 1,000 feet are large in Korea and Europe.

iv. Since it is generally more probable that clear skies or good weather will exist at a point in the atmosphere than throughout a consecutive sequence of points (flight path), the capability to navigate in-the-weather may generally be more important than the capability to deliver a weapon in-the-weather.

List of Figures and Tables

CLEAR SKIES AT ALTITUDE

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HQ USAF/SAGW

This paper describes a simple method for estimating the chance of remaining in-the-clear on 0-1000 nautical mile flights at various altitudes in three theaters of operation. The estimates provided are based upon climatological probabilities of sky cover in 15 layers of the atmosphere from the earth's surface to 55,000 feet altitude over a given location (1). Methodology described below is based upon studies of how cloud conditions decorrelate with distance. Figures 1 and 2 illustrate how total cloud cover throughout the depth of the atmosphere decorrelates with distance. Generally, after 600 miles cloud conditions become independent of each other in a linear fashion. It is reasonable to expect that these correlations are preserved layer by layer through the depth of the "free atmosphere" which generally begins about 5000 feet above sea level. Below, in the "planetary boundary layer", correlations are less persistent. Studies by the Air Force Geophysics Laboratory (2) indicate that sky cover observations decorrelate after distances of about 175 miles. Thus depending upon altitude, at least two distance scales are necessary to compute probabilities of maintaining clear skies at altitude.

The probability of continuous clear skies at an altitude over a distance can be represented by:

$$P = P_{oz}C_zD_z$$

where:

P_{oz} = Probability of clear skies at altitude Z over a given location

C_z = Coefficient describing loss of probability per unit distance at altitude Z

D_z = Distance traveled at altitude Z

$C_z = (P_{oz} - P^2_{oz})/Do$, where Do = scale distance over which correlation goes to zero. After a distance of Do, $P = P^2_{oz}$

Do = 600 miles for flight above either 6500 feet MSL (flat terrain) or 10,000 feet MSL (rough terrain)

Do = 175 miles below either 6500 feet MSL or 10,000 feet MSL depending upon terrain

Figure 3 illustrates how the probability of clear skies over a point in central Europe varies with altitude.

For example, the probability of an airplane being in clear skies during winter over a location in central Europe at an altitude between 3500 and 6500 feet is about 0.34. Approaching the surface, the probability improves to 0.67, illustrating the utility of being able to operate at lower altitudes under the

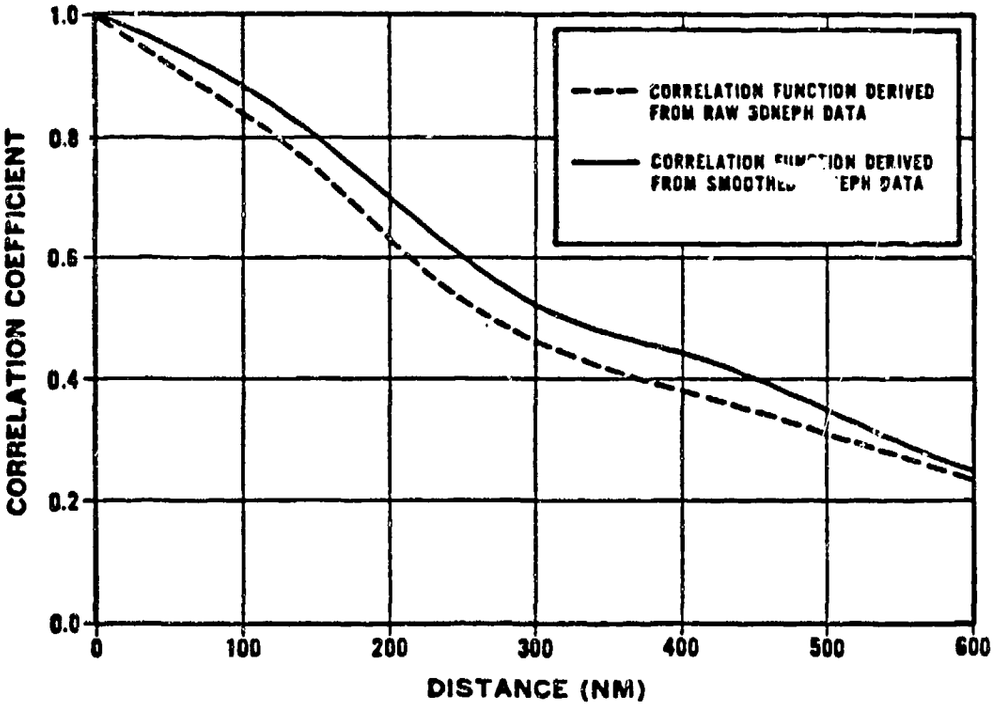


Figure : 1 Comparison of Spatial Correlation Functions Derived from Raw and Smoothed 3DNEPH Data for Box 22, January. The correlation functions illustrate the typical effect of smoothing, that is, smoothing slightly increases the spatial correlation coefficients.

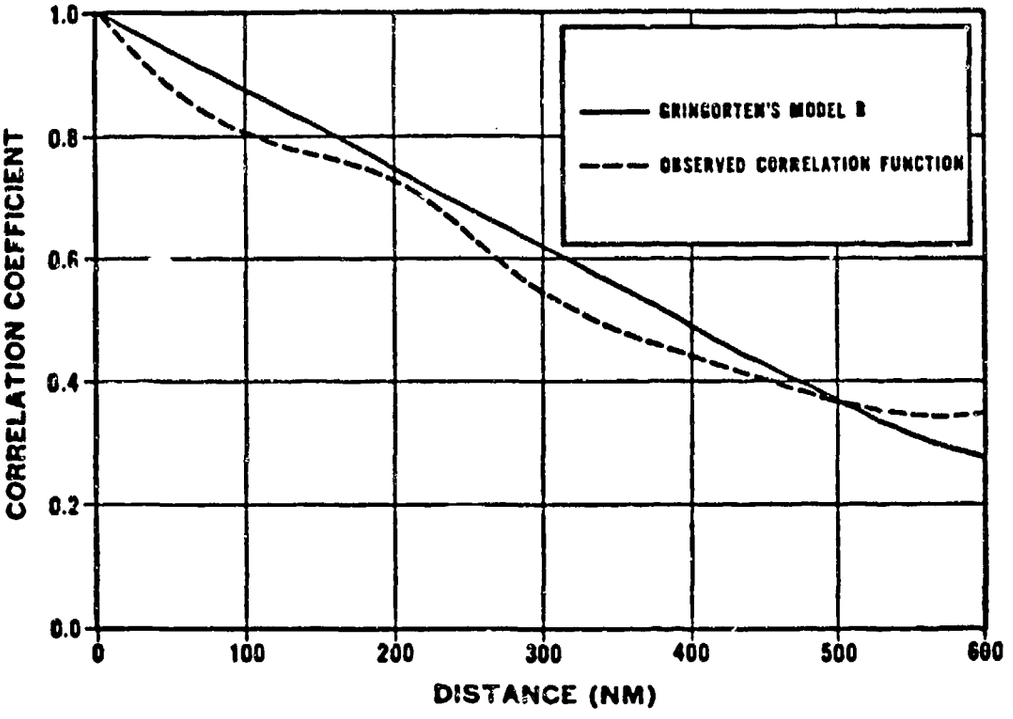
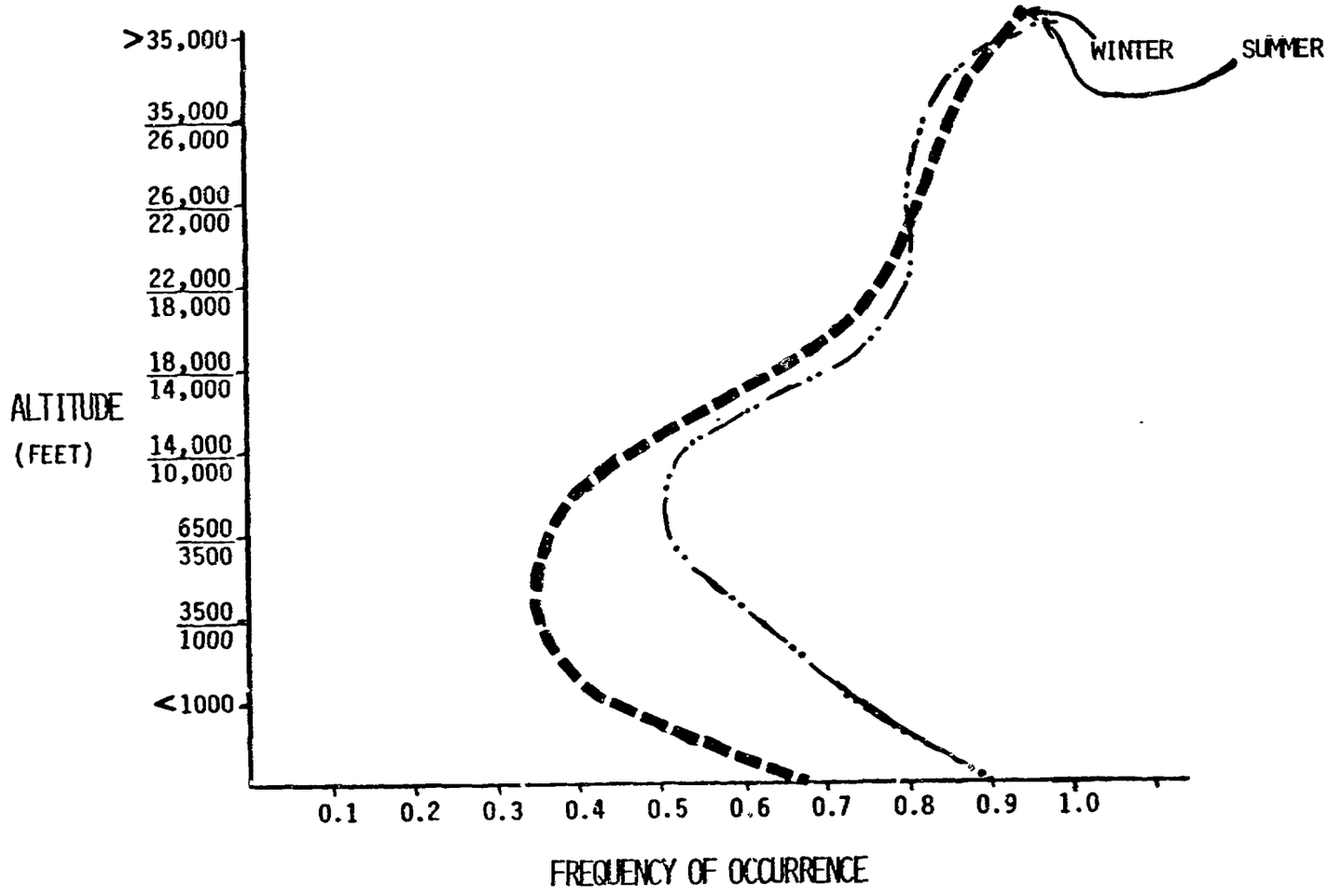


Figure: 2 Comparison of the Gringorten Model-B Spatial Correlation Function for a Scale Distance of 17.0 km and a Curve Derived from Smoothed 3DNEPH Data for Box 14, January. The Gringorten curve has been fitted to the observed data by the least squares method with a RMSE of 0.05.

FIGURE 3: PROBABILITY OF CLEAR SKIES IN CENTRAL EUROPE AS A FUNCTION OF ALTITUDE



weather. At higher altitudes, the probability improves such that there appears to be little difference in cloudiness above 14,000 feet from summer to winter.

Figures 4 and 5 illustrate how probabilities of cloud free or clear sky conditions decrease with distance flown at low and high altitudes. Along the ordinate (distance = 0) of each figure is the probability of clear skies at a point for the indicated theater and season. Probabilities of flying in-the-clear for a distance are given by moving along the abscissa for the distance of interest, going vertical to the curve of interest (location, season, time of day), and noting the expected frequency of occurrence along the ordinate. For example, the probability of staying in the clear over central Europe, between 3500 and 6500 feet, for 100 nautical miles, in winter, at night is approximately 0.18. If you fly 230 miles, this probability goes to zero. Similarly, the same probability over Korea in winter is about 0.51, going to zero after 460 miles of flight.

Tables 1 - 6 provide specific numbers of the above probabilities for the three theaters of concern (Europe, Korea, Mideast).

This paper was written to meet immediate AF/RDQT needs for this type of information. A more precise study of the probability of maintaining flight in clear conditions is planned by AF/SAGW as a new cloud data base is made operational.

Figure: 4 CLEAR SKIES DURING FLIGHT

ALTITUDE: 3500-6500 FEET

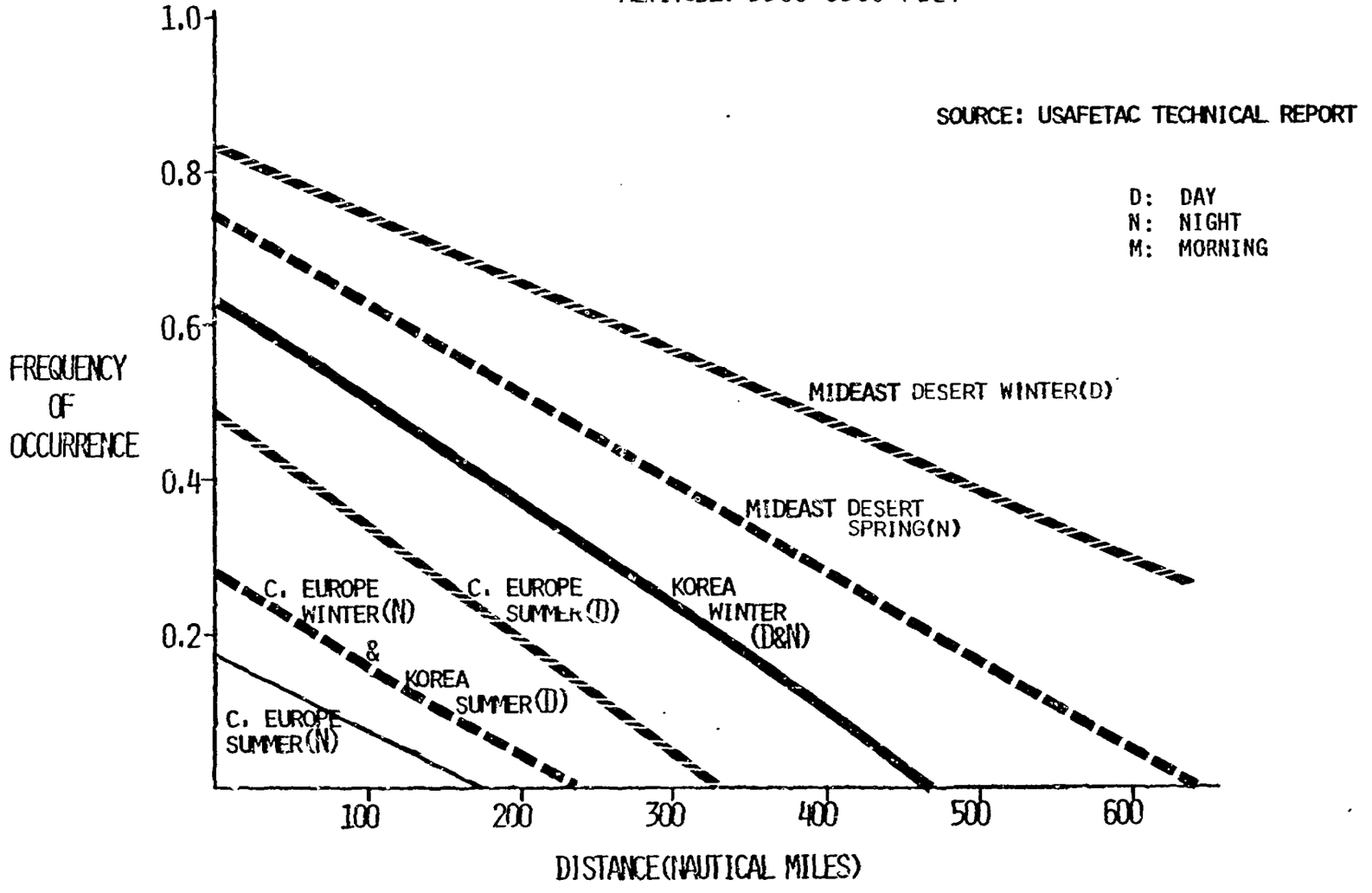


Figure: 5 CLEAR SKIES DURING FLIGHT

ALTITUDE: 18,000-22,000 FEET

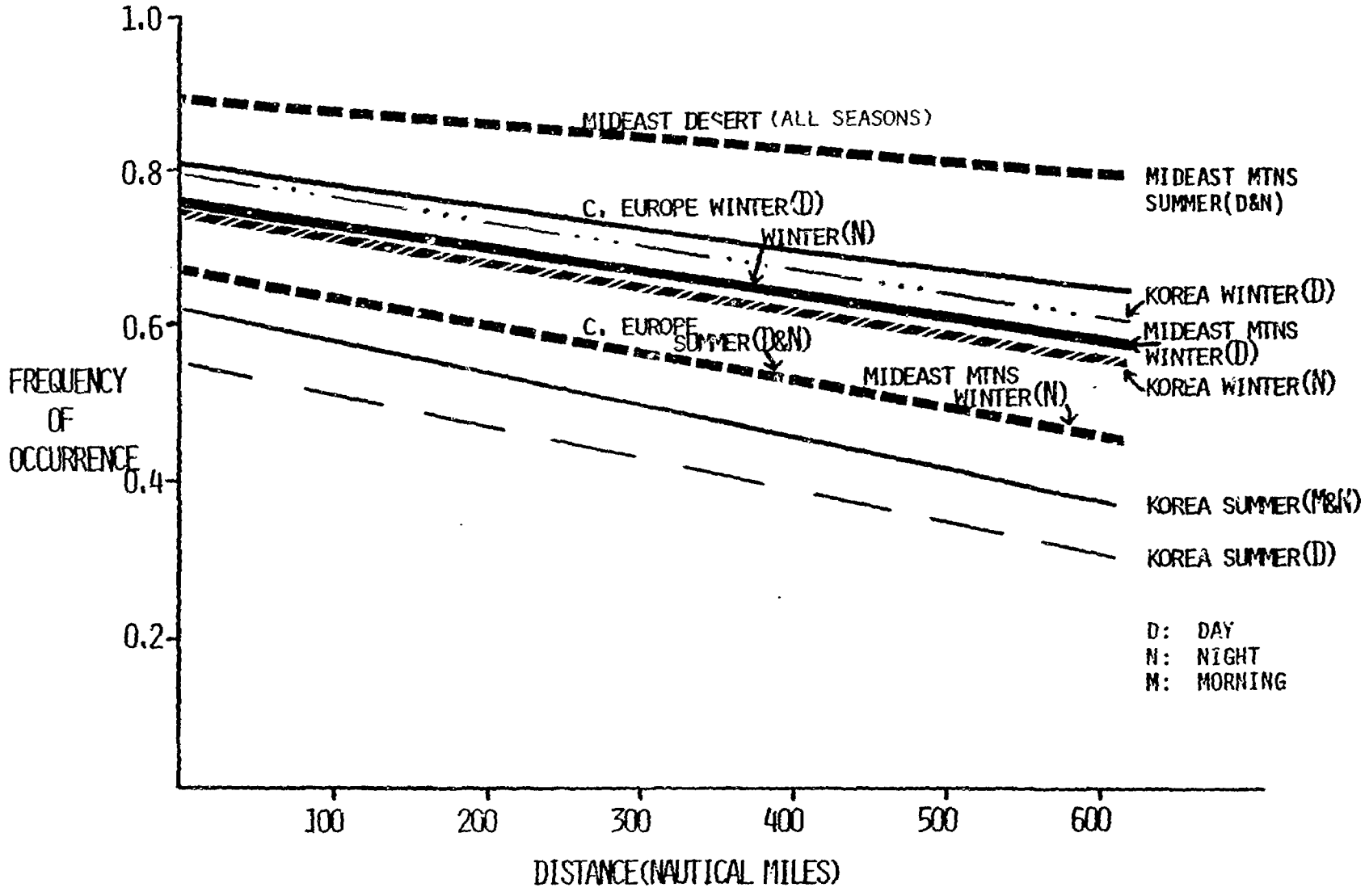


TABLE 1 PROBABILITIES OF MAINTAINING CLEAR SKIES AT ALTITUDE OVER VARIOUS DISTANCES

CENTRAL EUROPE - SOUTHERN MOUNTAINS

ALTITUDE (Ft)	*	DISTANCE (MILES) 0			100			200			400			600			1000		
		M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
≥35,000	W	.93	.96	.95	.92	.95	.94	.91	.95	.93	.89	.93	.92	.86	.92	.90	.82	.90	.87
	S	.96	.97	.95	.95	.97	.94	.95	.96	.93	.93	.95	.92	.92	.94	.90	.90	.92	.87
35,000	W	.86	.89	.83	.84	.87	.81	.82	.86	.78	.78	.82	.74	.74	.79	.69	.66	.73	.59
26,000	S	.84	.87	.83	.82	.85	.81	.80	.83	.78	.75	.75	.74	.71	.76	.69	.62	.68	.59
26,000	W	.82	.82	.75	.80	.80	.72	.77	.77	.69	.72	.72	.63	.67	.67	.56	.57	.57	.44
22,000	S	.81	.84	.77	.78	.82	.74	.76	.80	.71	.71	.75	.65	.66	.71	.59	.55	.62	.47
22,000	W	.77	.78	.73	.74	.75	.70	.71	.72	.66	.65	.67	.60	.59	.61	.53	.47	.49	.40
18,000	S	.80	.80	.76	.77	.77	.73	.75	.75	.70	.69	.69	.64	.64	.64	.58	.53	.53	.46
18,000	W	.65	.66	.59	.61	.62	.55	.57	.59	.51	.50	.51	.43	.42	.44	.35	.27	.29	.19
14,000	S	.73	.71	.69	.70	.68	.65	.66	.64	.62	.60	.57	.55	.53	.50	.48	.40	.37	.33
14,000	W	.44	.45	.42	.40	.41	.38	.36	.37	.34	.28	.29	.26	.19	.20	.18	.03	.04	.01
10,000	S	.53	.50	.50	.49	.46	.46	.45	.42	.42	.36	.33	.33	.28	.25	.25	.11	.08	.08
10,000	W	.36	.37	.37	.23	.24	.24	.10	.10	.10	-	-	-	-	-	-	-	-	-
6,500	S	.50	.46	.37	.36	.32	.24	.21	.18	.10	-	-	-	-	-	-	-	-	-
6,500	W	.34	.33	.30	.24	.20	.18	.10	.07	.06	-	-	-	-	-	-	-	-	-
3,500	S	.55	.47	.24	.41	.33	.14	.27	.19	.03	-	-	-	-	-	-	-	-	-
3,500	W	.40	.39	.34	.26	.25	.21	.13	.12	.08	-	-	-	-	-	-	-	-	-
1,000	S	.71	.58	.49	.59	.44	.35	.47	.30	.20	.24	02	-	.00	-	-	-	-	-
< 1,000	W	.66	.66	.70	.53	.53	.58	.40	.40	.46	.15	.15	.22	-	-	-	-	-	-
	S	.89	.80	.90	.83	.71	.85	.78	.62	.80	.67	.43	.69	.55	.25	.59	.33	-	.39

M: MORNING W: WINTER
A: AFTERNOON S: SUMMER
N: NIGHT

SOURCE: USAFETAC REPORT, "AREA AVERAGE CLOUD LAYER DISTRIBUTION DATA FOR CENTRAL EUROPE, THE MIDDLE EAST, AND KOREA", 8 FEB 82

CONDITIONS: Basic data is for a point within the area concerned. Based upon correlation studies of cloud observations, conditions above 10,000 feet are assumed independent after a distance of 600 miles and conditions below 10,000 feet are assumed independent after 175 miles. A linear decrease in correlation between is assumed.

TABLE 2. PROBABILITIES OF MAINTAINING CLEAR SKIES AT ALTITUDE OVER VARIOUS DISTANCES

CENTRAL EUROPE - NORTHERN PLAINS

ALTITUDE (Ft)	*	DISTANCE (MILES) 0			100			200			400			600			1000		
		M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
≥ 35,000	W	.94	.95	.93	.93	.94	.92	92	.93	.91	.90	.92	.89	.88	.90	.86	.85	.87	.82
	S	.97	.98	92	.97	.98	.91	.96	.97	.90	.95	.97	.87	.94	.96	.85	.92	.95	.80
35,000	W	.77	.83	.69	.74	.81	.65	.71	.78	.62	.65	.74	.55	.59	.69	.48	.47	.59	.33
26,000	S	.76	.79	.65	.73	.76	.61	.70	.73	.57	.64	.68	.50	.58	.62	.42	.46	.51	.27
26,000	W	.84	.84	.77	.82	.82	.74	.80	.80	.71	.75	.75	.64	.71	.71	.59	.62	.62	.47
22,000	S	.84	.88	.70	.82	.86	.67	.80	.84	.63	.75	.81	.56	.71	.77	.49	.62	.70	.35
22,000	W	.79	.80	.76	.76	.77	.73	.73	.75	.70	.68	.69	.64	.62	.64	.58	.51	.53	.46
18,000	S	.83	.86	.68	.81	.84	.64	.78	.82	.61	.74	.78	.53	.69	.74	.46	.59	.66	.32
18,000	W	.65	.67	.59	.61	.63	.55	.57	.60	.51	.50	.52	.43	.42	.45	.35	.27	.30	.19
14,000	S	.71	.75	.59	.68	.72	.55	.64	.69	.51	.57	.63	.43	.50	.56	.35	.37	.44	.19
14,000	W	.50	.50	.46	.46	.46	.42	.42	.42	.37	.33	.33	.29	.25	.25	.21	.08	.08	.05
10,000	S	.57	.56	.46	.53	.52	.42	.49	.48	.37	.41	.40	.29	.32	.31	.21	.16	.15	.05
10,000	W	.46	.45	.44	.42	.41	.40	.38	.37	.36	.29	.29	.28	.21	.20	.19	.05	.04	.03
6,500	S	.58	.52	.41	.54	.48	.37	.50	.44	.33	.42	.35	.25	.37	.27	.17	.17	.10	.00
6,500	W	.34	.34	.29	.21	.21	.17	.08	.08	.05	-	-	-	-	-	-	-	-	-
3,500	S	.46	.39	.17	.32	.25	.09	.18	.12	.00	-	-	-	-	-	-	-	-	-
3,500	W	.39	.40	.34	.25	26	.21	.12	.13	.08	-	-	-	-	-	-	-	-	-
1,000	S	.63	.50	.41	.50	.36	.27	.36	.21	.13	.10	-	-	-	-	-	-	-	-
< 1,000	W	.71	.72	.72	.59	.60	.60	.47	.49	.49	.24	.26	.26	.00	.03	.03	-	-	-
	S	.89	.81	.91	.83	.72	.86	.78	.63	.82	.67	.46	.72	.55	.28	.63	.33	-	.44

*M: MORNING
A: AFTERNOON
N: NIGHT

W: WINTER
S: SUMMER

SOURCE: USAFETAC REPORT, "AREA AVERAGE CLOUD LAYER DISTRIBUTION DATA FOR CENTRAL EUROPE, THE MIDDLE EAST, AND KOREA", 8 FEB 82

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TABLE 3. PROBABILITIES OF MAINTAINING CLEAR SKIES AT ALTITUDE OVER VARIOUS DISTANCES

MIDEAST - MOUNTAINS

ALTITUDE(Ft)	*	DISTANCE (MILES) 0			100			200			400			600			1000		
		M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
≥ 35,000	W	.88	.91	.81	.86	.90	.78	84	.88	.76	.81	.86	.71	.77	.83	.66	.70	.77	.55
	S	.97	.99	96	.97	.99	.95	.96	.99	.95	.95	.98	.93	.94	.98	.92	.92	.97	.90
35,000	W	.77	.80	.65	.74	.77	.61	.71	.75	.57	.65	.69	.50	.59	.64	.42	.47	.53	.27
26,000	S	.92	.96	.88	.91	.95	.86	.90	.95	.84	.87	.93	.81	.85	.92	.77	.80	.90	.70
26,000	W	.81	.82	.74	.78	.80	.71	.76	.77	.68	.71	.72	.61	.66	.67	.55	.55	.57	.42
22,000	S	.95	.97	.92	.94	.91	.91	.93	.90	.90	.92	.87	.87	.90	.85	.85	.87	.80	.80
22,000	W	.75	.78	.67	.72	.75	.63	.69	.72	.60	.63	.67	.52	.56	.61	.45	.44	.49	.30
18,000	S	.89	.90	.89	.87	.89	.87	.86	.87	.86	.82	.84	.82	.79	.81	.79	.73	.75	.73
18,000	W	.68	.68	.59	.64	.64	.55	.61	.61	.51	.53	.53	.43	.46	.46	.35	.32	.32	.19
14,000	S	.79	.84	.78	.76	.82	.75	.73	.80	.72	.68	.75	.67	.62	.71	.61	.51	.62	.49
14,000	W	.57	.56	.48	.53	.52	.44	.49	.48	.40	.41	.40	.31	.32	.31	.23	.16	.15	.06
10,000	S	.75	.82	.63	.72	.80	.59	.69	.77	.55	.63	.72	.47	.56	.67	.40	.44	.57	.24
10,000	W	.65	.63	.62	.52	.50	.48	.39	.36	.35	.13	.10	.08	-	-	-	-	-	-
6,500	S	.92	.94	.91	.88	.91	.86	.84	.88	.82	.75	.81	.72	.67	.75	.63	.50	.62	.44
6,500	W	.75	.74	.72	.64	.63	.60	.54	.52	.49	.32	.30	.26	.11	.08	.03	-	-	-
3,500	S	.96	.98	.96	.94	.97	.94	.92	.96	.92	.87	.94	.87	.83	.91	.83	.74	.87	.74
3,500	W	.73	.71	.71	.62	59	.59	.50	.47	.47	.28	.24	.24	.05	.00	.00	-	-	-
1,000	S	.96	.97	.95	.94	.95	.92	.92	.94	.90	.87	.90	84	83	87	79	74	80	68
< 1,000	W	.89	.88	.93	.83	.82	.89	.78	.76	.86	.64	.64	.78	.55	.52	.71	33	28	56
	S	.97	.98	.99	.94	.97	.98	.95	.96	.98	.94	.94	.97	.90	.91	.96	.87	87	.93

*M: MORNING
A: AFTERNOON
N: NIGHT

W: WINTER
S: SUMMER

SOURCE: USAFETAC REPORT, "AREA AVERAGE CLOUD LAYER DISTRIBUTION DATA FOR CENTRAL EUROPE, THE MIDDLE EAST, AND KOREA", 8 FEB 82

CONDITIONS: Basic data is for a point within the area concerned. Based upon correlation studies of observations, conditions above 10,000 feet are assumed independent after a distance of 600 miles and conditions below 10,000 feet are assumed independent after 175 miles. A linear decrease in correlation between is assumed.

TABLE 4. PROBABILITIES OF MAINTAINING CLEAR SKIES AT ALTITUDE OVER VARIOUS DISTANCES

MID EAST - DESERT

ALTITUDE (Ft)		DISTANCE (MILES) 0			100			200			400			600			1000		
	*	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
	W	.98	.96	.95	.98	.95	.94	97	.95	.93	.97	.93	.92	.96	.92	.90	.95	.90	.87
≥35,000	Sm	.98	.99	.97	.98	.99	.96	.97	.99	.96	.97	.98	.95	.96	.98	.94	.95	.97	.92
	Sp	.95	.97	.93	.94	.96	.92	.93	.96	.91	.92	.95	.89	.90	.94	.86	.87	.92	.82
35,000	W	.91	.92	.89	.90	.91	.87	.88	.90	.86	.86	.87	.82	.83	.85	.79	.77	.80	.73
I	S	.92	.94	.91	.91	.93	.90	.90	.92	.88	.87	.90	.86	.85	.88	.83	.80	.85	.77
26,000	Sp	.85	.88	.81	.83	.86	.78	.81	.84	.76	.77	.81	.71	.72	.77	.66	.64	.70	.55
26,000	W	.92	.92	.87	.91	.91	.85	.90	.90	.83	.87	.87	.79	.85	.85	.76	.80	.80	.68
I	S	.93	.92	.91	.92	.91	.90	.91	.90	.88	.89	.87	.86	.86	.85	.83	.82	.80	.77
22,000	Sp	.89	.87	.85	.87	.85	.83	.86	.83	.81	.82	.79	.77	.79	.76	.72	.73	.68	.64
22,000	W	.91	.91	.89	.90	.90	.87	.88	.88	.86	.86	.86	.82	.83	.83	.76	.77	.77	.73
I	S	.90	.91	.90	.89	.90	.89	.87	.88	.87	.84	.86	.84	.81	.83	.81	.75	.77	.75
18,000	Sp	.88	.87	.85	.86	.85	.83	.84	.83	.81	.81	.79	.77	.77	.76	.72	.70	.68	.64
18,000	W	.90	.88	.87	.89	.86	.85	.87	.84	.83	.84	.81	.79	.81	.77	.76	.75	.70	.68
I	S	.87	.88	.88	.85	.86	.86	.83	.84	.84	.79	.81	.81	.76	.77	.77	.68	.70	.70
14,000	Sp	.86	.87	.86	.84	.85	.84	.82	.83	.82	.78	.79	.78	.74	.76	.74	.66	.68	.66
14,000	W	.76	.76	.72	.73	.73	.69	.70	.70	.65	.64	.64	.59	.58	.58	.52	.46	.46	.38
I	S	.84	.88	.81	.82	.86	.78	.80	.84	.76	.75	.81	.71	.71	.77	.66	.62	.70	.55
10,000	Sp	.75	.78	.68	.72	.75	.64	.69	.72	.61	.63	.67	.53	.56	.61	.46	.44	.49	.32
10,000	W	.78	.77	.75	.75	.74	.72	.72	.71	.69	.67	.65	.63	.61	.59	.56	.49	.47	.44
I	S	.84	.89	.83	.82	.87	.81	.80	.86	.78	.75	.82	.74	.71	.79	.69	.62	.73	.59
6,500	Sp	.81	.84	.72	.78	.82	.69	.76	.80	.65	.71	.75	.59	.66	.71	.52	.55	.62	.38
6,500	W	.81	.82	.76	.72	.74	.66	.63	.65	.55	.46	.48	.34	.28	.31	.13	-	-	-
I	S	.84	.89	.83	.76	.83	.75	.69	.78	.67	.53	.67	.51	.38	.55	.35	.07	.33	.02
3,500	Sp	.79	.85	.72	.69	.78	.60	.60	.70	.49	.41	.56	.26	.22	.41	.03	-	.12	-
3,500	W	.84	.85	.78	.76	78	.68	.69	.70	.58	.53	.56	.39	.38	.41	.19	.07	.12	-
I	S	.86	.90	.85	.79	.85	.78	.72	.80	.70	.58	.69	.56	.45	.59	.41	.17	.39	.12
1,000	Sp	.83	.89	.78	.75	.83	.68	.67	.78	.58	.51	.67	.39	.35	.55	.19	.02	.33	-
	W	.95	.94	.95	.92	.91	.92	.89	.88	.89	.84	.81	.84	.79	.75	.79	.68	.62	.68
< 1,000	S	.97	.97	.98	.95	.95	.97	.94	.94	.96	.90	.90	.94	.87	.87	.91	.80	.80	.87
	Sp	.96	.97	.96	.94	.95	.94	.92	.94	.92	.87	.90	.87	.83	.87	.83	.74	.80	.74

*M: MORNING
A: AFTERNOON
N: NIGHT

W: WINTER
S: SUMMER
Sp: SPRING

SOURCE: USAFETAC REPORT, "AREA AVERAGE CLOUD LAYER DISTRIBUTION DATA FOR CENTRAL EUROPE, THE MIDDLE EAST, AND KOREA", 8 FEB 82

CONDITIONS: Basic data is for a point within the area concerned. Based upon correlation studies of observations, conditions above 10,000 feet are assumed independent after a distance of 600 miles and conditions below 10,000 feet are assumed independent after 175 miles. A linear decrease in correlation between is assumed.

REFERENCES: USAFETAC TN-81-004, Oct 81; Lund, I. & Granthum, D., "Estimating the Joint Probability of a Weather Event at two Locations", Journal of Applied Meteorology, Vol 18 #1, Jan '79.

TABLE 5. PROBABILITIES OF MAINTAINING CLEAR SKIES AT ALTITUDE OVER VARIOUS DISTANCES

NORTH KOREA

ALTITUDE (Ft)	*	DISTANCE (MILES) 0			100			200			400			600			1000		
		M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
≥ 35,000	W	.88	.80	.90	.86	.77	.89	.84	.75	.87	.81	.69	.84	.77	.64	.81	.70	.53	.75
	S	.78	.73	.83	.75	.70	.81	.72	.66	.78	.67	.60	.74	.61	.53	.69	.50	.40	.60
35,000	W	.81	.70	.84	.78	.66	.82	.76	.63	.80	.70	.56	.75	.66	.49	.71	.55	.35	.62
26,000	S	.62	.55	.66	.58	.51	.62	.54	.47	.59	.46	.39	.51	.38	.30	.44	.22	.14	.29
26,000	W	.91	.91	.91	.90	.90	.90	.88	.88	.88	.86	.86	.86	.83	.83	.83	.77	.77	.77
22,000	S	.79	.69	.82	.76	.65	.80	.73	.62	.77	.68	.55	.72	.62	.48	.67	.51	.33	.57
22,000	W	.86	.87	.88	.84	.85	.86	.82	.83	.84	.78	.79	.81	.74	.76	.77	.65	.68	.70
18,000	S	.74	.61	.77	.71	.57	.74	.68	.53	.71	.61	.45	.65	.55	.37	.59	.42	.21	.47
18,000	W	.74	.76	.69	.71	.73	.76	.68	.70	.73	.61	.64	.68	.55	.58	.62	.42	.46	.51
14,000	S	.55	.43	.59	.51	.39	.55	.47	.35	.51	.39	.26	.43	.30	.18	.35	.14	.02	.19
14,000	W	.71	.75	.75	.68	.72	.72	.64	.69	.69	.57	.63	.63	.50	.56	.56	.37	.44	.44
10,000	S	.43	.36	.49	.39	.32	.44	.35	.28	.41	.27	.21	.32	.18	.13	.24	.02	.02	.07
10,000	W	.72	.75	.74	.69	.72	.71	.65	.69	.68	.59	.63	.61	.52	.56	.55	.38	.44	.42
6,500	S	.42	.36	.47	.38	.32	.43	.34	.28	.39	.26	.21	.30	.18	.13	.22	.01	.02	.05
6,500	W	.62	.58	.64	.48	.44	.51	.35	.30	.38	.08	.02	.11	-	-	-	-	-	-
3,500	S	.29	.18	.36	.17	.10	.22	.05	.01	.10	-	-	-	-	-	-	-	-	-
3,500	W	.64	.60	.67	.51	46	.54	.38	.33	.42	.11	.05	.16	-	-	-	-	-	-
1,000	S	.31	.20	.37	.19	.11	.24	.07	.02	.10	-	-	-	-	-	-	-	-	-
< 1,000	W	.89	.90	.92	.83	.85	.88	.78	.80	.84	.67	.69	.75				.33	.39	.50
	S	.77	.80	.81	.67	.71	.72	.57	.62	.63	.37	.43	.45	.16	.25	.28	-	-	-

*M: MORNING
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W: WINTER
S: SUMMER

SOURCE: USAFETAC REPORT, "AREA AVERAGE CLOUD LAYER DISTRIBUTION DATA FOR CENTRAL EUROPE, THE MIDDLE EAST, AND KOREA", 8 FEB 82

CONDITIONS: Basic data is for a point within the area concerned. Based upon correlation studies of observations, conditions above 10,000 feet are assumed independent after a distance of 600 miles and conditions below 10,000 feet are assumed independent after 175 miles. A linear decrease in correlation between is assumed.

TABLE 6. PROBABILITIES OF MAINTAINING CLEAR SKIES AT ALTITUDE OVER VARIOUS DISTANCES

SOUTH KOREA

ALTITUDE (Ft)	*	DISTANCE (MILES) 0			100			200			400			600			1000		
		M	A	N	M	A	N	M	A	N	M	A	N	M	A	N	M	A	N
≥ 35,000	W	.95	.92	.96	.94	.91	.95	.93	.90	.95	.92	.87	.93	.90	.85	.92	.87	.80	.90
	S	.86	.83	.87	.84	.81	.85	.82	.78	.83	.78	.74	.79	.74	.69	.76	.66	.59	.68
35,000	W	.84	.76	.87	.81	.73	.85	.80	.70	.83	.75	.64	.79	.71	.58	.76	.62	.46	.68
26,000	S	.68	.59	.69	.64	.55	.65	.61	.51	.62	.53	.43	.55	.46	.35	.48	.32	.19	.33
26,000	W	.84	.80	.85	.81	.77	.83	.80	.75	.81	.75	.69	.77	.71	.64	.72	.62	.53	.64
22,000	S	.67	.60	.69	.63	.56	.65	.60	.52	.62	.52	.44	.55	.45	.36	.48	.30	.20	.33
22,000	W	.78	.74	.80	.75	.71	.77	.72	.68	.75	.67	.61	.69	.61	.55	.64	.49	.42	.53
18,000	S	.61	.55	.63	.57	.51	.59	.53	.47	.55	.45	.39	.47	.37	.30	.40	.21	.14	.24
18,000	W	.77	.77	.79	74	.74	.76	.71	.71	.73	.65	.65	.68	.59	.59	.62	.47	.47	.51
14,000	S	.57	.58	.57	.53	.54	.53	.49	.50	.49	.41	.42	.41	.32	.34	.32	.16	.17	.16
14,000	W	.66	.69	.71	.62	.65	.68	.58	.62	.64	.51	.55	.57	.44	.48	.50	.29	.33	.37
10,000	S	.45	.49	.49	.41	.45	.45	.37	.41	.41	.29	.32	.32	.20	.24	.24	.04	.07	.07
10,000	W	.70	.75	.73	.67	.72	.70	.63	.69	.66	.56	.63	.60	.49	.56	.53	.35	.44	.40
6,500	S	.49	.54	.57	.45	.50	.53	.41	.46	.49	.32	.37	.41	.24	.29	.32	.07	.13	.16
6,500	W	.57	.53	.64	.43	.39	.51	.29	.25	.38	.00	-	.11	-	-	-	-	-	-
3,500	S	.31	.20	.44	.19	.11	.30	.07	.02	.16	-	-	-	-	-	-	-	-	-
3,500	W	.67	.70	.75	.54	58	.64	.42	.46	.54	.16	.22	.32	-	-	.11	-	-	-
1,000	S	.44	.41	.58	.30	.27	.44	.16	.13	.30	-	-	.02	-	-	-	-	-	-
< 1,000	W	.85	.91	.90	.78	.86	.85	.70	.82	.80	.56	.72	.69	41	63	.59	.12	.44	.39
	S	.76	.83	.83	.66	.75	.75	.55	.67	.67	.34	.51	.51	.13	.35	.35	-	.02	.02

*M: MORNING
A: AFTERNOON
N: NIGHT

W: WINTER
S: SUMMER

SOURCE: USAFETAC REPORT, "AREA AVERAGE CLOUD LAYER DISTRIBUTION DATA FOR CENTRAL EUROPE, THE MIDDLE EAST, AND KOREA", 8 FEB 82

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REFERENCES

1. "Cloud Forecast Simulation Model", Whitten, R.C., Berecek, E.M., Sladen, J.G., USAFETAC TN-81-004, Oct '81.

2. Lund, I., and Granthum, D., "Estimating the Joint Probability of a Weather Event at two Locations", J. of Applied Meteorology, Vol 18 #1, Jan '79.

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1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A144005	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Clear Skies at Altitude		5. TYPE OF REPORT & PERIOD COVERED Final (Oct 82 - May 83)
		6. PERFORMING ORG. REPORT NUMBER 22926
7. AUTHOR(s) Lt Col Roger E. Christensen		8. CONTRACT OR GRANT NUMBER(s) NONE
9. PERFORMING ORGANIZATION NAME AND ADDRESS HQ United States Air Force ACS/Studies and Analyses Pentagon, Washington DC 20330		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS As in 9 above		12. REPORT DATE May 1983
		13. NUMBER OF PAGES 15
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) NA		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

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Weather, Clouds, Probability, Europe, Korea, Mideast

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This paper provides statistics on the probability of clear sky as a function of altitude as well as estimates of how these probabilities change with distance traveled. Information is provided for Central Europe, North and South Korea, and desert and mountainous regions of the Mideast.

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